James, J. (2016). *Less use of scientific terminology in the primary school classroom: a means of concept development?*. Paper presented at NARST Annual International Conference, Baltimore, United States.

LESS USE OF SCIENTIFIC TERMİNOLOGY IN THE PRIMARY SCIENCE CLASSROOM: A MEANS OF CONCEPT DEVELOPMENT?

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ABSTRACT:

The language of science has the potential to aid high order conceptual explanation, but emphasis on verbal correctness can frequently limit children's ability to conceptualise scientific ideas. This study takes a socio-cultural perspective and investigates whether an approach that separated the language and conceptual dimensions of science teaching could influence the discourse and learning of primary age children. Planning meetings were carried out with teachers in which concepts were isolated from the scientific terms traditionally associated with them. Recordings were made of classroom discourse and of the interviews that took place with the teachers. Data was analysed for cohesion in discourse and the level of exploratory discourse that took place. This analysis indicated that there was an increased focus on exploratory discourse in the classroom with enhanced confidence in explaining concepts using everyday language. Evidence was also seen of greater identity affiliation with the social discourse of science for both staff and pupils, particularly among less able boys and those with literacy difficulties. The study reveals the importance of pedagogical approaches that focus on language and conceptual development for engaging children who may experience identity conflict in the science classroom.

BACKGROUND

Research in science education has stressed the importance of fostering discursive practices in the classroom (Driver *et al*, 1994), so that children can start to appropriate the social language of science and construct their own meaning. Learning in science involves making the shift from having "informal knowledge" gained through experience to constructing "scientific conceptual knowledge" involving more abstract ideas. The literature highlights the key role of language in mediating this shift as it provides a structure for thinking and constructing understanding. (Mercer, 1995; Vygotsky, 1978).

Yet there are those that contend that in learning the language of science school children are being inducted into playing the "game" of doing science (Halliday & Martin, 1993). Language no longer appears to describe or connects to a child's experience, as learning to talk science involves construing those experience in a particular way that uses precise language. This acculturation into successful participation in science tends to be reinforced by feedback from teachers and is illustrated by the following observation from Dykstra *et al* (1992).

Very often I have seen students praised for thinking like a scientist when it is clear that the students are simply making noises which sound scientific. (P.615)

The precise, technical nature of this langauge presents problems for many children, but it is the perceived acceptability of only certain discourse modes that may cause more significant issues related to identity (Lemke, 1990). Hence as children are introduced to the discourse of science they may experience cultural insecurity, limiting identity with the subject and potentially resulting in underachievement.

School science teachers have been shown to have a literacy approach that does not contextualise scientific language and may therefore exacerbate feelings of alienation that pupils are experiencing (Yore et al, 2004). Given this perspective, students may perceive participation in the sociocultural domain of science as an act of denial of group identity. Other marginalised groups, including the less able, those who struggle with literacy, or have English as an additional language, can also experience identity conflicts in the science classroom, and language can exacerbate those feelings of social and cultural isolation from the practices of science (Gee, 2001). The "language" of science of course involves more than scientific terminology, also including mathematical, symbolic, and epistemological components, but it is terminology that enables access to those components which many contend are at the heart of the practices and discourse of the subject (Duschl *et al*., 2007). This language is, in Bernstein's notions on codes (1990), restricted and elaborated, and is more accessible to children from wealthier backgrounds who have been acculturated into use of such elaborated codes within their homes and communities.

This paper takes the position that language plays an important part in mediating students' science learning, providing a structure for thinking and constructing understanding, and that dialogic processes should be promoted in the classroom. The Vygotskian perspective highlights the centrality of language in enabling learners to move to conceptual explanations for everyday experiences (Vygotsky, 1998), hence the importance of discourse such as Mercer's "exploratory talk" (1995) A dialogic approach also acknowledges the sociocultural values and subjectivity that children and their teachers bring to the classroom, and facilitates group interactions that collectively generate new learning. A number of researchers have propsed that there may be benefits in focusing on development of concepts in pupils' own social language so that they can engage in the dialogic process without constraint and loss of identity (Hynd et al, 1994). Brown and Ryoo (2008) developed studies built around a theoretical framework proposing that complex terminology limits pupils' learning and that use of vernacular language may be more productive. Their work saw some learning gains, attributed to a reduction in disengagement and inferiority, when concepts were introdued using everyday language only. However the study was a small scale quantitative one, focusing on second language learners, and had its limitations.

THE RESEARCH: CONTEXT AND PURPOSE

The English National Curriculum for Science underwent significant revisions in 2013. In part this was an attempt to halt England's deteriorating performance in international comparison exercises, as illustrated by the most recent OECD PISA results which showed that the country had now slipped to 18th place for science in 2012, compared to 4th place in 2000 (OECD, 2013). Also of concern was the fact that, compared with other high achieving countries, England tends to have a greater proportion of lower achievers in science (NfER, 2014). In the revised National Curriculum there is an increased emphasis placed on the development of scientific vocabulary in the 5-11 age range, as illustrated by the following excerpt:

Pupils should read and spell scientific vocabulary correctly and with confidence, using their growing word reading and spelling knowledge. (DfE, 2013, P. 13)

There is an assumption here that discourse using selective scientific terminology is the only valid way to describe and explain phenomena. Hence there is pressure on primary school teachers in England to focus on developing scientific language, so guiding children into specific types of dialogue. Often this is done through provision of vocabulary in decontextualised settings, with perfunctory definitions, that do not result in understanding of the underlying concepts that the language signifies. This is then extended into the assessment process, where the use of the "correct" terminology and dialogue is then often taken as a proxy for comprehension of scientific ideas. So language ceases to support the development of conceptual understanding because new language, divorced from social and cultural context, has no meaning.

The work of Brown and Ryoo (2008) suggests teachers can support understanding through using everyday language terms prior to the introduction of scientific words. This seeks to develop children's confidence in their conceptual understanding and subsequent engagement with scientific dialogue, while maintaining interest in and identity with science. In the light of concerns about the role of terminology in the new National Curriculum in England, research was carried out that sought to investigate the "concept-first" approach in the primary science classroom. The latter has the advantage of being a setting that has a more explicit focus on literacy, but is an under-investigated one in terms of research. A small scale study was conducted that focused on the conceptual development of pupils in their own social language before bringing in the social language of science, investigating the effects on discourse and learning. Links between language, identity and engagement have been highlighted, and attitudes to school and science have been shown to decline more in more deprived areas (Roden, 2000). It was appropriate therefore to set the research in schools that were situated in areas of social deprivation. The work then sought to address the following research objectives that explore dialogue in the science classroom, interpreting this through a sociocultural lens that recognises the influence of the teacher.

* How does an approach that separates language and conceptual aspects of science teaching influence the discourse and learning of primary school age children from socially disadvantaged communities?

* What influence do the beliefs and attitudes of the children's teachers have on the classroom context?

DESIGN AND PROCEDURE:

As part of a project funded by the University of Bristol, three schools were selected to participate, all serving disadvantaged communities in the same geographical area, as evidenced by a range of socio-economic indicators, and they also had a high proportion of pupils with special educational needs. In two of the schools head teachers volunteered teachers of Year 3-5 children (ages 8-10) through a consultative process, based on a project summary that I had provided. While in the third I was asked to meet with a group of potential teachers to outline the project and then decide who would carry the work forward. This resulted in a total of five teachers participating in the project, pair of teachers in two schools, and a single teacher in the third school.

Data Collection: The two primary data sources were teacher interviews and classroom observation records. The former were semi-structured in nature to enable an exploration of teachers' perspectives on language and science. This part of the data collection also included recordings of the joint planning meetings held with teachers. In the two school were pairs of teachers were involved, I took part in the regular planning meetings that the teachers held weekly, while in the third school I convened a one off meeting with the teacher concerned.

Brown and Ryoo (2008) established a planning approach that had three distinct phases: 1) a phase where content and concepts were constructed in everyday language 2) an explicit language phase, and (3) the introduction of the explicit language phase in the classroom. The first two phases were developed here in the planning meetings, where forthcoming science topics were deconstructed in terms of their linguistic and conceptual facets. This process determined what science content was to be taught, the scientific terminology associated with the content and teaching approaches that delayed the use of that language. For example, in the topic of plant reproduction, thought was given to how plant parts and processes might be described in everyday language, e.g. the stigma being conceptualised as a "pollen catcher". An example of a planning outcome in relation to plant reproduction is presented in appendix 1. The phase, where scientific language was introduced, was left to teachers to determine as they trialled strategies in classrooms over a period of four months.

In two of the schools teachers felt it would be easier to carry out an experimental type study where parallel groups were either a) taught primarily using everyday language, and scientific terminology was only introduced at the end, or, b) taught using every day and scientific language. Acknowledging participants' experiences and views can be an important part of the constructivist paradigm (Cresswell, 2003), and so this approach was adopted, though no quantitative testing was carried out.

Classroom observation was unsystematic and broad in nature, so assisting in gaining perspectives on dialogical interaction. Initial observations were carried out to gauge the baseline of scientific discourse and so enable assessment of any changes in the quality of children's talk.

Data Analysis: Interview and classroom data was subject to thematic analysis that classified teacher attitudes and perspectives in relation to affiliation with everyday or scientific language (Corbin & Strauss, 2014). Transcripts of interviews, planning meetings and classroom episodes were systematically coded to enable identification of data relevant to these affiliations. Representative quotations have then been selected to illustrate these affiliations.

Qualitative analysis of teacher-pupil and pupil-pupil discourse was carried out to gauge levels of exploratory talk, based on methods developed by Mercer (1995). Exploratory talk is a way of using language to construct knowledge and makes collaborative reasoning explicit. In line with Mercer's analysis the quality of exploratory discourse was achieved through monitoring of key linguistic terms such as "because", "I think" or "I agree".

The other means used to analyse the constructivist nature of discourse was framed around the notion of cohesion in classroom dialogue, and the preponderance of anaphoric and exophoric cohesion. Discourse that promotes cohesion with the preceding "text" is classified as anaphoric (Hassan, 2000) while narrative that links to contexts outside the "text" are defined as exophoric. Anaphoric cohesion tends to be a feature of elaborated codes, including scientific discourse, where narrative tends to be decontextualized and mediated by formal, symbolic concepts. Recordings of classroom discourse were therefore transcribed and subject to analysis of their degree of cohesion and whether it was exophoric or anaphoric.

FINDINGS, ANALYSIS AND DISCUSSION

Teachers' Perspectives:

Even at the initial planning stage a comment such as the following revealed the uncertainty that some teaching staff felt in adopting an approach that limited the use of scientific vocabulary and revealed their affinity to the latter.

I like the idea but don't really feel comfortable with a novel approach. I think children like getting to grips with the key words, though they don't always really get their meaning. It makes you feel that they are making progress if they know the words. Year 3 teacher (School B)

Baseline observations showed that there was an orientation towards literacy activities within the classrooms that predicated the introduction of scientific discourse. While time was given for eliciting pupils' ideas in their own social language, the transition to introducing new concepts was often proceeded by introduction of new language or associated with the introduction of new terminology. The following comment perhaps illustrated something of the rationale for this:

I find it quite easy to discuss what children know already, but towards the end of a topic, when you're trying to bring in the new ideas, it would feel a bit empty not using the key words. Year 4 teacher (School A)

Even where teachers had volunteered to participate there was a strong affiliation with scientific terminology, perhaps revealing the identity issue that primary school teachers, often non-specialists, can have when teaching science. Gee (2001) refers to the invoking of language as a means of conveying identity and it was clear here that the removal of scientific terminology may have exacerbated identity conflict as teachers struggled with their role as a science teacher. There was confusion over how the approaches might be applied to other topics and evidence that teachers' own affiliation with science was draped around the key words that they were trying to avoid.

The approach that separated the conceptual and language dimensions worked most effectively when teachers focused on observational experience and carefully guided children towards the more abstract ideas. With no assumption of knowledge of technical terms or introduction of new words, children were able to develop understanding in their own social language. While ideas expressed were not always a complete scientific description, e.g. "*The tube helps to put the man seed down to the ovary"*, there was a sense in the case of work on plant reproduction that pupils had grasped the key processes. The Brown and Ryoo study (2008) noted the improved ability of students to explain concepts and show understanding using everyday and scientific language.

Several teachers showed stronger affiliation to both vernacular and scientific language, having a clearer perception of their place and role. One teacher went as far as not even explicitly introducing scientific language as they felt it to be more important that children carried forward an understanding of the concepts. All the teachers reported that the work had motivated less able learners, particularly boys with weak literacy skills. An increased focus on discussion in the classroom was evident, with one Year 5 teacher commenting:

I think it's changed my teaching approach as I've focused more on explanations and discussion. There's been better engagement, particularly by those with weak literacy. (School C)

However the same teacher still revealed their affiliation with scientific language:

Some of the more able girls might be frustrated as they want to know the words. However I do feel they made progress and that they can use the ideas of forces. (Year 5 teacher, School C)

Where the approach was carried out with one of two parallel groups teachers showed a tendency to volunteer comparisons as the following comment reveals.

Initially I was quite worried as it felt quite different as I wanted to use the key words, but then soon got used to it. I've then found that we've been going at a quicker pace (compared to the parallel group) as we've been less concerned about vocabulary. Year 3/4 teacher (School C)

While this highlighted some benefits the remark of another teacher showed that children questioned whether they were missing out on something by not using scientific words and that their learning might be devalued.

One issue is that there has been some cross-over with the other group – a few pupils keep asking me what words (scientific) mean. Year 4 teacher (School B).

Classroom Discourse:

Cohesion: The groups which delayed use of scientific terminology tended to display certain commonalities in their discourse. The narrative tended to be more cohesive with exophoric ties being particularly evident. For example during talk on forces a teacher used exophoric linkage to help pupils relate concepts to visual contexts such as a tennis racquet (the transcript and analysis are presented in Table 1). These observations are consistent with those noted in Harris and Williams (2007) where cohesion was important in helping children to make sense of questions and develop a scientific view of phenomena. The anaphoric linking of children's responses to previous utterances by other children and the teacher also encourages meaning making, which while not resulting in fully formed scientific conceptions does help children of a young age to develop partial explanations of quite complex phenomena. Progress was made through linkage to concepts expressed in everyday language, e.g. a child later in the lesson attempted an explanation for the tennis racquet phenomena, "the force push is down (anaphoric link) when the racquet pushes downwards."

Table 1: School B. Year 5 class – a group that hadn't used scientific terminology

Speaker	Transcription	Analysis
Teacher	What's happening to the plane? Pause. Pupil A?	Exophoric link
Pupil A	The plane is like producing forces like the air.	Exophoric link, though use of "forces" may be anaphoric. Claim made, no reason.
Teacher	And….	Possibly hints at anophoric link
Pupil A	The air is pushing it and the force is pushing it through the air.	Reiterates the claim
Teacher	What's happening with the tennis racquet?	Exophoric link
Pupil A	Well you're like hitting it and forcing it to go in the direction you've hit it.	"You're" – exophoric
Teacher	That's alright. Well done A, you've given us quite a good start. B?	Implication that questions might remain unanswered
Pupil B	Um… the airplane and the tennis ball, it's the same force. The bottle is… I think hot air is trapped inside it and so the bottle moves.	"I think", "so" – features of exploratory talk
Teacher	How does it move?	
Pupil B	By the air pushing it maybe?	Anaphoric response. Speculative answer
Teacher	(Shows approval for the idea by intake of breath) C?	
Pupil C	I thought that the water can't get in to make it sink because it's got stuff trapped inside and so it can't get in.	High level of exploratory talk – "I thought, because, so…."

Where scientific terminology was explicitly used by the teacher narrative cohesion was often more of a struggle (see Table 2). For example an initial question was posed in work on forces that strove for anaphoric cohesion: “if something’s got lots of air resistance, what might happen to it”, but this resulted in muddled responses and uncertainty on the part of the children. Attempts to use scientific terminology by the teacher also perhaps reveal conceptual confusion on their part as air resistance is not something that is possessive.

Table 2: School A – Year 4 class. Scientific terminology was used throughout the forces topic.

Speaker	Transcription	Analysis
Teacher	If something’s got lots of air resistance what might happen to it? Pupil X?	Anaphoric link of air resistance with action.
Pupil X	It can stick to something.	Responds to teacher, but muddled link.
Teacher	Stick to something, what do you mean by that?	
Pupil X	Like its stuck……. friction (*whispered)*	Short statements where reasons are not explicit
Teacher	I think you’re thinking about friction. It doesn’t stick things, it’s a force between two surfaces. High friction is when it’s hard to move things, low is when it’s easy to move. Do you think that with air resistance it’s going to be high or low?	The interchange is more “disputational” as assertions are made with few reasons. Anaphoric link attempted between “high/low” in relation to the two force types

Exploratory talk: The use of such talk is illustrated by pupil C in the dialogue presented in Table 1:

“I <u>thought</u> that the water can’t get in to make it sink <u>because</u> it’s got stuff trapped inside <u>and so</u> it can’t get in.”

Discourse analysis, through monitoring use of terms such as “I think, because, I agree”, revealed that where use of terminology was delayed in classrooms there was often greater evidence of exploratory talk. Table 3 presents the monitoring of key features of such talk from the audio recordings of the two classroom lessons featured in Tables 1 and 2.

Table 3: Incidence of key features of exploratory talk: comparing lessons where scientific terminology was employed and not employed.

Linguistic feature	Incidence in School B lesson in where scientific terminology was not used	Incidence in School A lesson where scientific terminology was explicitly employed
“I think/reckon”	19	5
“Because/cause”	14	7
“I agree”	7	1

It must be recognised that the dataset here is small, but nevertheless appear to indicate some increase in exploratory talk where the use of scientific terminology is restricted. There was also a greater willingness for children to offer tentative explanations, whereas in the classrooms where scientific terminology was explicitly employed children seemed less willing to engage in scientific reasoning and hypothesising, possibly through concern over being verbally correct, e.g. in a discussion on forces a child was heard whispering, in slightly embarrassed terms, the word “friction” without any attaching any reason for the utterance.

One would be wary of ascribing any causality to this, as the pedagogic approaches of the teachers and the sociocultural practices of those classrooms will exert significant influence, however the adoption of everyday language may give the teacher and children the confidence to engage in pedagogical approaches that encourage exploratory talk.

CONCLUSIONS

The study has shown some benefits in limiting the use of scientific language, in terms of the quality of discourse and engagement in the science classrooms of primary schools serving disadvantaged communities. Language and engagement are acknowledged to be important mediators for learning and development of long-term understanding, but the study would need extending longitudinally to examine longer-term effects. Mercer et al. (1999) noted that even where significant changes were observed in children’s discourse, gains made in performance tests were much less noticeable.

This study offered some encouragement though that pupils from low socio-economic backgrounds were able to participate more readily in scientific practices and dialogue when the need for verbal correctness was reduced. The most skilful teachers seemed to be able to “neutralise” social status by enabling pupils to participate in narrative that focused on concepts, rather than language. Additionally there appeared to be particular impact on certain groups of pupils; the less able and those with literacy difficulties, which may indicate the influence of incorporating children’s social language practice into the discourse of the science classroom, so reducing identity conflict. An increased focus on exploratory discourse and reasoning was seen, with some evidence of enhanced confidence in explaining concepts using everyday language and possibly scientific language. Removal of concerns over precise language use enabled cohesion in classroom narrative and may have given teachers the confidence to promote language as a tool for reasoning. Encouragingly this was associated with increased engagement by both teachers and pupils with science and its social discourse.

The planning stage was seen to be critical and enabled teachers to see more clearly the difficulties, misconceptions, language issues, and conceptual problems encountered by children. Participant teachers adjusted to the “concept-first” approach, but found it much more problematic as to when and how to introduce scientific terminology; their affiliation to science language remained strong. Additionally concerns were expressed as to how assessment might take place without a clearly specified body of language. It was evident as well that weak subject knowledge, or lack of confidence in it, exerted an effect on teachers’ ability to employ a socio-constructivist, “concept-first” approach.

While socio-constructivism is advocated by many in the science education field, there are a number of problems asscoiated with the paradigm: the need to appropriate the complex language of science, and issues of power and identity that exist for both children and teachers. However the results of this exploratory study have shown some potential for tackling these issues.

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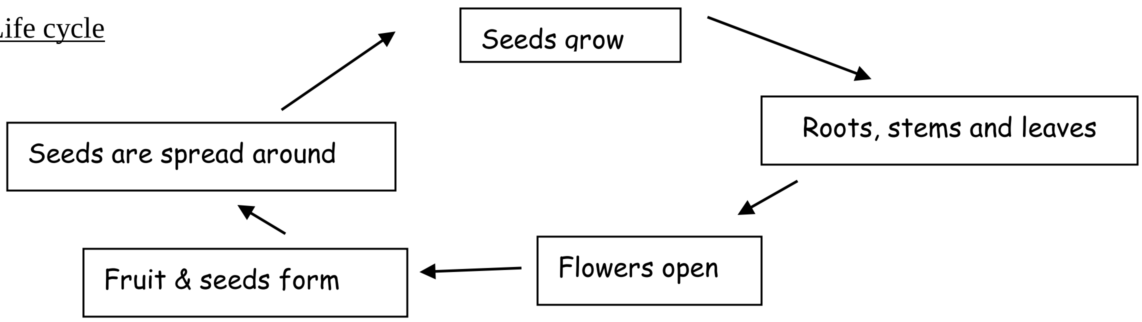
Appendix 1: Example of an outcome from a planning meeting where a topic has been deconstructed

Plant Reproduction

Key ideas: The green parts of plants make food by using light from the sun. Plants also have flowers so that they can make new plants. All living things need to produce more of their own kind to replace ones that die. Flowering plants reproduce by making **seeds.** Before a seed can grow into a new plant they have to be **fertilized** by **pollen.** Pollen comes from another plant during a process called **pollination (pollen transfer/movement)).**

Life cycle



Plant parts – useful to focus on rings of structures, working from the outside - sepals, petals, stamens, carpel

Plant part	**Description**	**Job**
Petal	Brightly coloured. They have a scent.	Help "export" pollen- - they attract pollen carriers
Sepals	Green – like little leaves around the outside of the flower. Smaller than the petals	Protect the flower when it is in the "bud" stage
Stamen	Male part of the plant - made up of the anther and filament	To make pollen
Anther	Yellow knob	Where pollen is made and stored
Filament	A thin stem/stalk – bendy – varies in length	Supports the anther - allows movement. Long – if pollination is by wind Short – if pollination is by insect
Carpel	Female part. Tall column/stalk in the middle of the plant with a swollen base and short branches at the top. 3 parts	To receive pollen and transfer it to the seed
Stigma	Top of the female part – like a landing stage	Where pollen lands
Style	A tube running between the top and bottom of the plant	To enclose the pollen tube as it grows down to the seed (ovary)
Ovary	Swollen base of the plant – holds tiny eggs	Holds eggs – seeds form here and it will become the fruit
Pollen	Yellow grains/specks/dust	"Male seed"

Processes:
Pollination: This is when pollen lands on a new flower
Fertilization: This is when the pollen and the egg meet
Seed dispersal: This is when the seed is spread around, away from the plant that made it
Germination : This is when the seed, having reached the ground, starts to grow into a new plant